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Compilation of SO2 and NOx Continuous Emission Monitoring Reliability Information

Entropy Environmentalists, Inc.
Research Triangle Park, NC

Prepared for

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This report presents the latest information on the reliability of SO_2 and NO_x CEM results, i.e.: (1) achievable CEM availability, (2) point-in-time CEM accuracy, and (3) the long-term capability of CEMs to provide accurate emission data.

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A Compilation of SO2 and NOx Continuous Emission Monitor Reliability Information

Prepared by:

James W. Peeler
Entropy Environmentalists, Inc.
Research Triangle Park,
North Carolina

Prepared for:

Louis R. Paley
Stationary Source Compliance Division
and
Anthony Wayne
Region VII

United States Environmental Protection Agency
SSCD Contract No. 68-01-6317

and

Darryl von Lehmden
and
Thomas Logan

Quality Assurance Division
United States Environmental Protection Agency
QAD Contract No. 68-02-3431

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Stationary Source Compliance Division
Washington, D.C. 20460

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EXECUTIVE SUMMARY

As air pollution control agencies emphasize the implementation of continuous emission monitoring (CEM)* programs and effective utilization of CEM results, the reliability of the monitoring data (i.e., the availability, accuracy, precision, and representativeness of monitoring results) increases in importance for both the affected source owner/operator and the control agency. This report presents the latest information on the reliability of SO_2 and NO_x CEM results, i.e.: (1) achievable CEM availability, (2) point-in-time CEM accuracy, and (3) the long-term capability of CEMs to provide accurate emission data.

The information in current literature shows that the CEM availability (data capture rate) levels are between 67 and 95 percent for SO_2 and NO_x CEMs. CEM availability is expected to vary on source-specific and source-category bases and to increase with additional operational experience.

Analysis of more than 119 relative accuracy tests (RATs) of SO_2 and NO_x CEMs shows that the four most common commercially available SO_2 and NO_x CEMs are capable of meeting the 20 percent "point-in-time" relative accuracy specification (both on a concentration and $lb/10^6$ Btu basis) on coal- and oil-fired steam generators with and without wet FGD systems.

The results of numerous RATs conducted after the initial demonstration of compliance with the Performance Specifications show that both SO_2 and NO_x CEMs continue to be capable of obtaining accurate data on a long-term basis under a wide variety of source conditions. No general deterioration in the SO_2 and NO_x CEMs' accuracy was apparent during the 24-month period following the initial demonstration of compliance.

* Throughout this document, the acronym CEM is used to mean both "continuous emission monitor" and "continuous emission monitoring." The specific connotation should be clear from the context in which it is used.

TABLE OF CONTENTS

I. Introduction..... 1

II. SO_2 and NO_x CEM Availability..... 3

Background..... 3

CEM Availability Estimates..... 5

References..... 8

III. SO_2 and NO_x CEM Accuracy..... 9

Background..... 9

Compilation of SO_2 and NO_x RAT Results..... 12

Long-Term CEM Performance..... 16

APPENDIX..... 23

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I. INTRODUCTION

The Environmental Protection Agency and many State air pollution control agencies are currently expanding the scope and implementation of SO_2 and NO_x continuous emission monitoring programs for stationary sources. Greater importance is being placed on CEM results for evaluating the adequacy of the operation and maintenance practices of source processes and control systems. In some cases, such as those sources subject to the recently promulgated NSPS (40 CFR 60, Subpart Da) requirements, SO_2 and/or NO_x CEM results are used to determine compliance with emission limitations. Clearly, the increased utilization of CEM reflects control agency efforts to achieve sustained emission reductions from stationary sources.

As control agencies emphasize the implementation of CEM programs and effective utilization of CEM results, the importance of obtaining reliable monitoring data increases for both the affected source owner/operator and the control agency. More specifically, the level of long-term monitor performance in terms of CEM availability, accuracy, precision, and representativeness is of fundamental importance.

Until recently, there has been a lack of long-term monitor performance evaluations. Although many CEMs have met the applicable Performance Specification requirements during an initial performance test, very few monitoring systems have been retested to demonstrate long-term accuracy. In addition, various CEM users have reported widely differing values of CEM availability (data capture rates). However, only very limited quantitative information has been available to determine the causes of CEM unavailability (i.e., unreliable CEM equipment, inappropriate applications of CEMs, and/or the inexperience of CEM users).

This report presents additional, recently available information about the long-term reliability of SO_2 and NO_x CEM results. The term "CEM reliability" is considered to be the degree to which source operators and control agencies may depend on CEM data to yield a consistent and valid measure of SO_2 and NO_x emission levels. This report addresses (1) achievable CEM availability, (2) point-in-time CEM accuracy, and (3) long-term capability of CEM to provide accurate data. The results and conclusions in this report are based on CEM availability values reported in current literature, numerous performance specification test results, and a number of performance audit results. This document does not attempt to specify achievable CEM availability and accuracy.

II. SO_2 and NO_x CEM AVAILABILITY

This section presents background information on CEM availability, including definitions of terminology and a brief discussion of the major CEM availability factors. Several estimates of availability are discussed for SO_2 and NO_x monitoring systems installed at electric utility steam generators. These estimates bracket the expected range of CEM availability for contemporary gas monitoring programs.

Background

The term "CEM availability" is the data capture rate exhibited by a continuous emission monitoring system. It is defined as the percentage of time a monitoring system is operating (i.e., sampling, analyzing, and recording emission data) relative to the total time the system is required to operate. This percentage does not incorporate the accuracy or precision of the CEM data.

The availability of SO_2 and NO_x CEM data affects the characterization of emission levels and/or process and control system performance at a given source. No CEM system can be expected to operate continuously over an extended period of time. Unforeseen malfunctions of various components and necessary routine maintenance and repairs will reduce the availability. Quantification of the achievable level of CEM availability will aid the control agency and the source operator in determining accurately both acceptable monitor performance and when to initiate corrective action.

CEM availability is dependent on a variety of factors, including the following.

(1) Reliability of specific instrumentation.

(2) Instrument maintainability and availability of spare parts.

(3) User's operational, repair, and trouble-shooting expertise (and/or the availability of service from the monitor vendor).

(4) Environmental conditions (exposure to weather, corrosive gases, and/or dusty environments, etc.).

(5) Site conditions (accessibility, adequacy of power supply and other utilities, presence of mechanical vibration, existence of microwave and/or radio frequency interference, etc.).

(6) Effluent conditions (temperature, pressure, flow rate, particulate loading, etc.).

7. User's dedication of manpower and prioritization of repair efforts during periods of monitor malfunction.

In view of the number of factors that affect CEM availability, the infinite combinations of these factors, and the varying degree of severity of specific problems encountered in actual practice, CEM availability must be expected to vary over time and from source to source. CEM availability is expected to increase over time on an industry-wide basis as unreliable instrumentation is excluded from the competitive CEM market, as unsuccessful approaches to the installation and operation of CEMs are identified, and as monitor operators gain necessary experience and develop appropriate quality control programs and cost effective preventive maintenance programs. Because of these time-dependent factors, the averaging period of all CEM availability estimates must be clearly identified to characterize adequately the many problems that detract from CEM availability.

CEM Availability Estimates

All of the factors discussed above increase the difficulty and decrease the usefulness of developing "average" CEM availability percentages to represent the level of monitor performance that can be reasonably achieved. A more realistic approach is to establish an expected or acceptable range of CEM availability values.

One notable attempt to characterize CEM availability was conducted by the Utility Air Regulatory Group (UARG) in response to the EPA September 18, 1979 proposal of Subpart Da requirements.[1] During the fall of 1978, UARG surveyed 71 electric utility companies. Survey responses from 63 companies provided information on a total of 539 emission monitoring channels (SO_2, NO_x, O_2, CO_2, and opacity) installed at 237 generating units throughout the U.S. In this survey, in which monitor availability is expressed on a monthly basis, 55 responses indicated an average availability of 67 percent for SO_2 monitoring channels, 50 responses indicated an average availability of 67 percent for NO_x monitoring channels, and 85 responses indicated an average availability of 76 percent for O_2 and/or CO_2 monitoring channels. It is emphasized that (1) the UARG survey included some monitors installed before the EPA promulgation of CEM requirements, (2) considerable advancements in CEM application technology and additional operating experience have been made since the survey was conducted, and (3) the survey results reflect to an indeterminate degree the relatively low level of control agency emphasis on the implementation of CEM programs that existed at the time the survey was conducted. Thus, although currently achievable CEM availability is expected to be somewhat greater than that indicated by the "average" results of the 1978 UARG survey, these results are nevertheless indicative of a minimum level of achievable CEM availability.

CEM availabilities achieved by two utility companies actively involved in CEM programs for some time are summarized in Table 1. The two companies are the Texas Utilities Generating Company[2] and The Montana Power Company[3]. The results over the five year period from 1977 to 1981 show significant improvement in SO_2 and NO_x availability. The improvement is attributed to increased overall experience of the monitor operators. Table 1 also shows that five of the six monitoring systems exhibited approximately 95 percent availability during 1980 and 1981.

A study of CEM data reported to the California South Coast and the Bay Area Air Quality Management Districts[4] provides further estimates of SO_2 and NO_x CEM availability. This study included data reported from November 1978 to April 1980 for 62 CEMs in the South Coast District, and data reported from July 1979 to December 1980 for 38 CEMs in the Bay Area District. A total of 33 SO_2 CEMs had achieved an average availability of 97.2 percent, and a total of 67 NO_x CEMs had achieved an average availability of 96.7 percent. These high availability figures may be the result of all the CEMs being installed on gas or oil-fired steam generators with no FGD systems. Therefore, these results may not accurately represent the achievable CEM availability for coal-fired boilers and/or units equipped with wet FGD systems.

The results of these three investigations probably represent the ultimate level of CEM availability; whereas, the results of the UARG 1978 survey probably represent the minimum acceptable level of CEM availability. The minimum data collection requirements, which are included in EPA's June 11, 1980 promulgation of Subpart Da (i.e., 18 hours per boiler operating day, and 22 days per 30 operating days, or approximately 75 percent) fall within the CEM availability range bounded by the above references.

TABLE 1.

REPORTED CEM AVAILABILITY

Station	Unit	Monitor	Percent Availability 1977	1978	1979	1980	1981
Martin Lake	1*	SO_2	86.1	88.6	100	97.7	97.4
Martin Lake	2*	SO_2	--	90.6	100	97.5	98.6
Martin Lake	3*	SO_2	--	--	49	94.1	36.9
Colstrip	1 and 2**	SO_2	84.1	92.5	95.7	96.6	96.2
Colstrip	1 and 2**	NO_x	88.9	90.1	94.8	96.5	95.7

* Texas Utilities Generating Company.

** Montana Power Company

References

[1] "Section IV - October/November 1978 Continuous Monitor Survey," An Evaluation of the Continuous Monitoring Requirements of the September 19, 1978 Subpart Da NSPS Proposal, pp. 72-96.

[2] Bill Bonner, "Continuous Emission Monitoring - Texas Utilities Generating Company's Experience," Proceedings, Continuous Emission Monitoring: Design, Operation and Experience Specialty Conference, pp. 62-69.

[3] David K. Nation, "Continuous Emission Monitoring Experience at Colstrip Units 1 & 2," Proceedings, Continuous Emission Monitoring: Design, Operation and Experience Specialty Conference, pp. 25-38.

[4] R.P. Hebert, W.C. Kelly, and W.J Mitchell, "Assessment of the Reliability of Continuous Emission Monitors Installed in Two California Air Quality Regions," Proceedings, Continuous Emission Monitoring: Design, Operation and Experience Specialty Conference, pp. 18-24.

III. SO_2 and NO_x CEM ACCURACY

Background information relevant to the measurement of gas CEM accuracy and the interpretation of CEM relative accuracy test results is presented in this section. Also, a compilation of relative accuracy test results is provided, giving both "point-in-time" CEM accuracies and capabilities of SO_2 and NO_x CEMs to achieve the level of performance required by both the existing and proposed relative accuracy specifications of Appendix B (40 CFR 60). Finally, the results of performance audits of SO_2 and NO_x CEMs are presented and discussed to provide a preliminary evaluation of long-term CEM accuracy for a number of sources.

Background

The accuracy of CEM data is of critical importance to both the control agency and the source owner/operator. To protect the interests of both parties, the CEM data must be sufficiently accurate to ensure valid conclusions and decisions. Clearly, the uncertainty-level of all conclusions based on the data decreases as the accuracy of the data improves.

Measurement accuracy is generally defined as the degree of agreement of a measured value with the "true" value (or the degree of agreement of the mean of a set of measurements with the corresponding "true" values). Traditionally, the accuracy of SO_2 and NO_x CEM data has been determined by conducting relative accuracy tests (RATs) in accordance with the requirements of Performance Specification 2, Appendix B, 40 CFR 60. The term "relative accuracy" reflects the fact that the accuracy of the CEM data is determined relative to the results obtained by performance of Reference Method Test procedures; the Reference Method results are presumed to be the "true" values

for this test. Historically, RATs have only been conducted during CEM Performance Specification Tests (PSTs); however, requirements to perform periodic RATs will probably be mandated as basic elements of most quality assurance programs. (See "A Compilation of Quality Assurance Procedures for SO_2 and NO_x Continuous Emission Monitoring Systems.") Also RATs may be conducted by the control agency as a central part of SO_2 and NO_x CEM performance audit programs.

To place the interpretation of CEM RAT results into the proper perspective, one must clearly understand how several procedural test requirements and a number of constraints affect the representativeness of the test results. According to the existing Performance Specification 2 (Appendix B, 40 CFR 60), the relative accuracy of SO_2 and NO_x CEM data is determined in units of concentration (ppm) from a series of nine measurements using Method 6 for SO_2 and Method 7 for NO_x. (Concurrent moisture sampling is also conducted, if needed, to adjust either the wet basis CEM data or the dry basis Reference Method data to the same moisture basis.)

The relative accuracy of SO_2 and NO_x CEMs is computed as the sum of (1) the absolute value of the mean from the differences between the 9 pairs of concurrent CEM and Reference Method results and (2) the 95 percent confidence interval associated with the observed differences. This sum is divided by the mean Reference Method value in order to express the relative accuracy as a percentage. The relative accuracy calculated using this procedure is actually expressed in terms of error; smaller relative accuracy values indicate better monitor performance. Performance Specification 2 requires the result of the RAT to be less than, or equal to, 20 percent for acceptable CEM performance.

Relative accuracy is affected by errors in the CEM data and the Reference Method data. The Reference Methods are not totally precise because of the

inherent variability and the expertise and ability of the tester. The confidence interval of the RAT determination reflects the precision among the paired CEM - Reference Method results; i.e., it is the sum of (1) the imprecision of the CEM data, (2) the inherent variability of the Reference Method results, and (3) the ability of the tester to conduct the Reference Method tests. For a particular RAT, the individual errors cannot be quantified. Therefore, the cause of an excessive confidence interval value (e.g., poor testing practices or poor CEM performance) cannot be objectively determined. Thus, while meeting the relative accuracy specification demonstrates that a CEM has provided accurate data during the test, failure to do so does not necessarily demonstrate that a CEM has provided inaccurate data.

The RAT covers an approximate nine-hour period and represents only the accuracy of the CEM data during that test period and at the effluent conditions encountered during the RAT. Thus, the RAT provides a "point-in-time" measure of CEM accuracy. A successful RAT only demonstrates that the CEM is capable of obtaining sufficiently accurate data for its intended use. The CEM accuracy actually achieved on a day-to-day basis is primarily dependent upon (1) the validity of the calibration procedure employed for the CEM, and (2) the manner in which the CEM operator performs the daily calibration procedure.

As a final note regarding the interpretation of RAT results, it is important to recognize that revisions to Performance Specifications 2 and 3 proposed first in the October 10, 1979, Federal Register, and subsequently reproposed in the January 26, 1981, Federal Register, significantly change th scope of the RAT. The presently promulgated specifications require that the relative accuracy of pollutant SO_2 and NO_x monitors be determined in units of concentration (ppm). There are no RAT requirements on the diluent (O_2 or

CO_2) monitor which is used to convert pollutant concentration measurements to units of the standard (lb/10^6 Btu) at fossil fuel-fired steam generators. The proposed revisions require that the RAT determination be conducted in units of the standard (lb pollutant/10^6 Btu) and thereby, provide a measure of the combined pollutant-diluent monitoring system accuracy. The proposed revisions provide for evaluation of the accuracy of the total CEM system (both pollutant and diluent monitors) in the same units of measurement that are used for reporting excess emissions to the control agency.

Compilation of SO_2 and NO_x RAT Results

The results of 41 RATs (in units of concentration) of 22 installed SO_2 CEMs and the results of 25 RATs (in units of concentration) of 15 installed NO_x CEMs are tabulated in the Appendix of this report. In addition, the results (expressed in units of lb/10^6 Btu) of 34 SO_2 RATs and the results of 19 NO_x RATs are provided for a subset of the same population of monitors. Table 2 summarizes the results of these tests in terms of meeting the existing and proposed relative accuracy specifications.

In evaluating the RAT results provided in the Appendix and summarized in Table 2, the following qualifications of the data base should be kept in mind:

(1) All tests were performed at coal- and oil-fired steam generators; some of the coal-fired installations were equipped with wet FGD systems.

(2) All RATs were performed either during the initial demonstration of compliance with Performance Specifications 2 and 3 or during announced performance audit programs conducted by various control agencies.

TABLE 2. SUMMARY OF SO_2 AND NO_x RELATIVE ACCURACY TEST RESULTS

Monitor	Pollutant	FGD Controls	Existing RA Requirements[1] No. of Monitors	No. of Tests	% of Tests ≤20% RA	Proposed RA Requirements[2] No. of Monitors	No. of Tests	% of Tests ≤20% of RA
LSI SM810	SO_2	NO	7	11	91%	6	9	100%
	SO_2	YES	2	9	89%	2	7	86%
	NO_x	NO	4	6	50%	3	4	25%
	NO_x	YES	2	9	100%	2	7	100%
DuPont 460	SO_2	NO	6	6	100%	6	6	100%
	SO_2	YES	1	3	67%	1	3	100%
	NO_x	NO	5	5	100%	5	5	100%
	NO_x	YES	0	0	---	0	0	---
Contraves Goerz GEM-100	SO_2	NO	2	3	67%	1	1	100%
	SO_2	YES	1	4	50%	1	4	50%
	NO_x	NO	2	3	67%	1	1	100%
	NO_x	YES	0	0	---	0	0	---
EDC DIGI 1400	SO_2	NO	1	1	100%	1	1	0%
	SO_2	YES	1	2	100%	1	1	100%
	NO_x	NO	2	2	50%	2	2	---
	NO_x	YES	0	0	---	-	-	---
CSI Monitor	SO_2	NO	1	2	100%	1	2	100%
All Monitors	SO_2	NO	17	23	91%	15	19	95%
	SO_2	YES	5	18	78%	5	15	80%
	NO_x	NO	13	16	69%	11	12	75%
	NO_x	YES	2	9	100%	2	7	100%

[1] Performance Specification 2, Appendix B, 40 CFR 60 (RA test performed in units of pollutant concentration - ppm)

[2] Proposed revisions to Performance Specifications 2 and 3, Federal Register, Vol. 46, No. 16 January 26, 1981 (RA test performed in units of the standard - $lbs/10^6$ Btu)

(3) Source maintenance personnel and/or monitor manufacturer service representatives are known to have made adjustments to the subject CEMs prior to the RATs in some cases.

In view of the above, the RAT results may not necessarily represent the performance of similar CEMs under dissimilar conditions. In addition, valid statistical inferences regarding the ability of randomly selected CEMs to meet relative accuracy specifications cannot be derived from the data base.

Within the limitations of the available data base, analysis of the included RAT results indicates:

(1) There is no apparent significant difference between the capabilities of SO_2 and NO_x CEMs to meet RAT specifications. (NO_x CEMs may have a slightly higher failure rate; however, this finding may be due to the limited data.)

(2) There is no apparent significant difference between the capabilities of CEMs installed at oil- and coal-fired facilities to meet RAT specifications.

(3) There is no apparent significant difference between the capabilities of CEMs installed at FGD equipped and non-FGD equipped facilities to meet RAT specifications. (SO_2 monitors did perform better at non-FGD sources; however, NO_x monitors generally performed better at FGD equipped sources. Again, these results may be attributable to the limited data.)

(4) CEMs manufactured by Lear Siegler, DuPont, Contraves Goerz, Environmental Data Corporation, and Columbia Scientific Industries have been shown to be capable of meeting RAT requirements of $\leq$20 percent, both in units of concentration (ppm) and in units of the standard (lb/10^6 Btu).

(5) Of the 53 SO_2 and NO_x RATs that had results in both units of concentration (ppm) and units of the standard (lb/10^6 Btu), (1) 6 CEMs failed to meet both the concentration and system relative accuracy specifications, (2) 3 CEMs failed only the concentration relative accuracy specification, and (3) 2 CEMs failed only the system relative accuracy specification. Therefore, changing the RAT specifications from the existing concentration basis to the proposed system basis would affect the status of only 5 CEMs (approximately 9 percent of the population) with respect to compliance with the relative accuracy specification.

(6) The minimum 95 percent confidence interval value observed in the results of 41 SO_2 RATs in units of concentration was 1.4 percent of the mean SO_2 concentration value; the minimum 95 percent confidence interval value observed in the results of 34 SO_2 RATs in units of lb/10^6 Btu was 2.2 percent of the mean SO_2 emission value.

(7) The minimum 95 percent confidence interval value observed in the results of 25 NO_x RATs in units of concentration was 2.0 percent of the mean NO_x concentration value; the minimun 95 percent confidence interval value observed in the results of 19 NO_x RATs in units of lb/10^6 Btu was 1.3 percent of the mean NO_x emission value.

Long-Term CEM Performance

The results of RATs conducted for 20 SO_2 CEMs at varying time intervals after the initial successful demonstration of compliance with Performance Specification 2 are shown in Figure 1. The same type of results for 7 NO_x CEMs are shown in Figure 2. For some of the SO_2 and NO_x CEMs, more than one RAT was conducted subsequent to the initial PST; at one source, a total of 7 RATs have been conducted over a period of 42 months.

In evaluating the long-term RAT results, the following qualifications should be kept in mind:

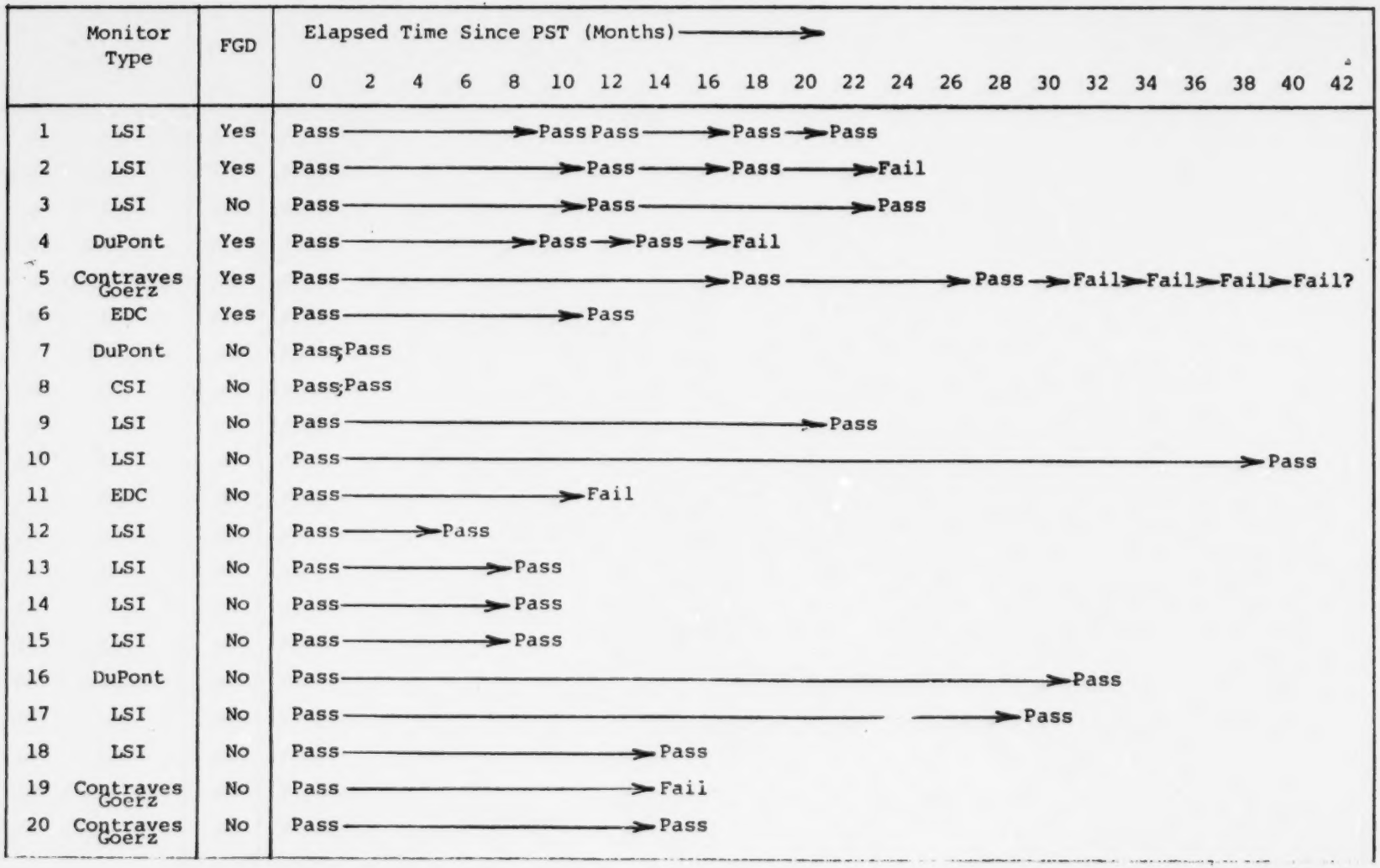
(1) All of the SO_2 and NO_x CEMs are installed at coal-fired steam generators except for the 2 NO_x CEMs installed at oil-fired facilities. Five of the SO_2 CEMs and two of the NO_x CEMs are installed on sources equipped with wet FGD systems.

(2) All of the RATs performed after the initial demonstration of compliance with Performance Specifications 2 and 3 were announced CEM performance audits.

(3) Source maintenance personnel and/or monitor manufacturer service representatives are known to have inspected and/or made adjustments to the subject CEMs prior to the RATs in eight cases.

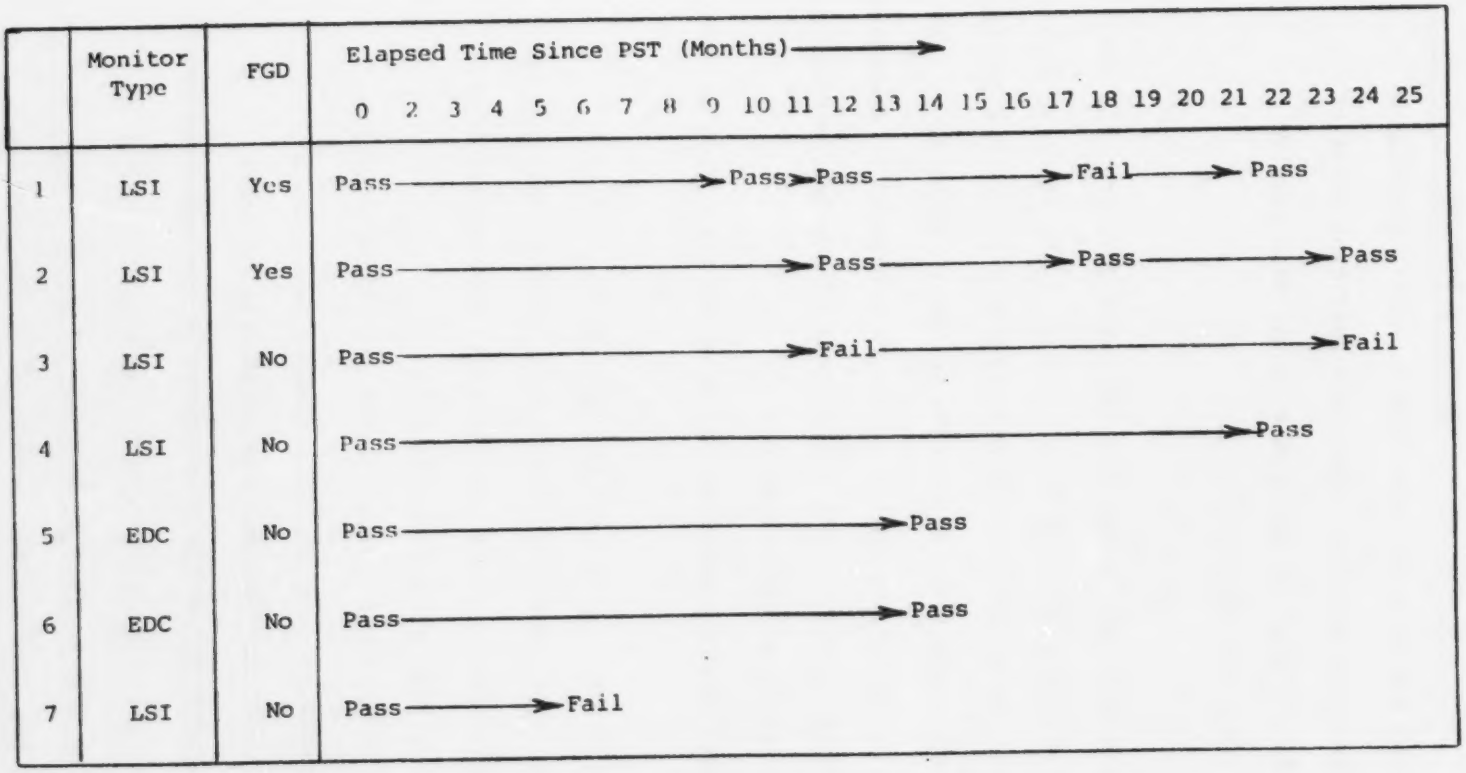
(4) In many cases, the initial RAT results were determined in units of concentration; these results are used even though all subsequent RAT values were determined in units of $lb/10^6$ Btu.

Figure 1. RELATIVE ACCURACY TEST RESULTS FOR SO_2 CEM PERFORMANCE AUDITS CONDUCTED AFTER SUCCESSFUL PERFORMANCE SPECIFICATION TESTS (PSTs)


Monitor Type
FGD
Elapsed Time Since PST (Months)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42
1 LSI Yes Pass Pass Pass Pass Pass
2 LSI Yes Pass Pass Pass Fail
3 LSI No Pass Pass Pass
4 DuPont Yes Pass Pass Pass Fail
5 Contraves Goerz Yes Pass Pass Pass Fail Fail Fail Fail?
6 EDC Yes Pass Pass
7 DuPont No Pass Pass
8 CSI No Pass Pass
9 LSI No Pass Pass
10 LSI No Pass Pass
11 EDC No Pass Fail
12 LSI No Pass Pass
13 LSI No Pass Pass
14 LSI No Pass Pass
15 LSI No Pass Pass
16 DuPont No Pass Pass
17 LSI No Pass Pass
18 LSI No Pass Pass
19 Contraves Goerz No Pass Fail
20 Contraves Goerz No Pass Pass

LSI = Lear Siegler SM810; DuPont = DuPont 460; Contraves Goerz = Contraves Goerz GEM-100; CSI = Columbia Scientific Industries; EDC = Environmental Data Corporation DIGI 1400.

Figure 2. RELATIVE ACCURACY TEST RESULTS FOR NO_x CEM PERFORMANCE AUDITS CONDUCTED AFTER SUCCESSFUL PERFORMANCE SPECIFICATION TESTS (PSTs)


Monitor Type
FGD
Elapsed Time Since PST (Months)
0 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
1 LSI Yes Pass Pass Pass Fail Pass
2 LSI Yes Pass Pass Pass Pass
3 LSI No Pass Fail Fail
4 LSI No Pass Pass
5 EDC No Pass Pass
6 EDC No Pass Pass
7 LSI No Pass Fail

LSI = Lear Siegler SM810; EDC = Environmental Data Corporation DIGI 1400.

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(5) All RATs performed after the initial PST were conducted by personnel from Entropy Environmentalists, Inc. in accordance with all applicable regulatory testing requirements and in accordance with Entropy's internal quality assurance program. Thus, a significant level of experimental control is applicable to all test results obtained after the initial PST.

The non-routine adjustments of the subject CEMs made just prior to the performance of the announced RATs may have influenced the level of monitor performance achieved. These non-routine adjustments and services probably increased the apparent capability of the CEMs to obtain valid data. The fact that all RATs performed after the initial PST were conducted by essentially the same testing personnel ensured the consistency of the test results and eliminated interlaboratory variance effects.

Overall, the gas CEM performance audits provided the following results:

(1) The 20 installed SO_2 CEMs met the applicable relative accuracy specification for 25 of the 33 audits conducted (4 of the 8 relative accuracy test failures were consecutive tests of the same monitoring system).

(2) 15 of the 20 SO_2 CEMs audited passed all of the relative accuracy tests.

(3) The 7 installed NO_x CEMs met the applicable relative accuracy specification for 9 of the 13 audits conducted (2 of the 4 relative accuracy test failures were consecutive tests of the same monitoring system).

(4) 4 of the 7 NO_x CEMs audited passed all of the relative accuracy tests that were conducted.

In evaluating the above results, it is important to note that: (1) there are no promulgated quality assurance requirements applicable to the audited CEMs, and (2) there are no promulgated requirements for the CEM operators to periodically test installed CEMs or to take necessary corrective actions where unacceptable performance is observed.

Although other results can be derived from the long-term CEM accuracy data obtained to date, there is insufficient information upon which to base any significant statistical analysis. Additional RATs of these and other installed SO_2 and NO_x CEMs are currently being planned and conducted. The results of these future tests will enhance the existing data base, both in terms of the number of monitors represented and the length of time for which results are available for the same monitors. However, the inclusion of these additional results is not expected to dramatically affect the overall characterization of CEM reliability.

APPENDIX
RELATIVE ACCURACY
TEST RESULTS

AVERAGE MONITOR PERFORMANCE DATA

Monitor	Fuel	Pollutant Gas	FGD System	Pollutant Concentration		System [lbs/10^6 Btu]	
				Relative Accuracy (%)	95% Confidence Level (%)	Relative Accuracy (%)	95% Confidence Level (%)
LSI	Coal	SO_2	YES	13.9	4.6	13.4	5.2
LSI	Coal	SO_2	NO	11.5	4.2	12.3	4.1
LSI	Coal	NO_x	YES	11.1	5.4	13.9	5.3
LSI	Coal	NO_x	NO	17.2	6.1	24.4	7.2
DuPont	Coal	SO_2	YES	16.7	11.9	11.2	7.2
DuPont	Coal	SO_2	NO	10.1	5.5	10.8	6.0
DuPont	Oil	SO_2	NO	10.1	3.1	13.4	3.6
DuPont	Coal	NO_x	NO	16.6	4.0	16.4	3.8
DuPont	Oil	NO_x	NO	13.3	5.2	14.4	5.1
Contraves	Coal	SO_2	YES	30.6	9.0	47.3	12.0
Contraves	Coal	SO_2	NO	16.4	3.5	7.5	4.6
Contraves	Coal	NO_x	NO	17.5	3.7	13.1	7.8
EDC	Coal	SO_2	YES	14.1	4.6	11.9	5.5
EDC	Coal	SO_2	NO	18.0	3.5	32.0	6.7
EDC	Oil	NO_x	NO	13.2	4.9	12.5	6.5
CSI	Coal	SO_2	NO	8.9	4.0	9.1	4.1

LSI MONITOR PERFORMANCE

SOURCES WITH FGD EMISSIONS CONTROL SYSTEMS

Source Code	Test Date	Pollutant Gas	Fuel Burned	Pollutant Concentration		System [lbs/10^6 Btu]	
				Relative Accuracy (%)	95% Confidence Level (%)	Relative Accuracy (%)	95% Confidence Level (%)
P-1	06/80	SO_2	Coal	17.5	3.5	---	---
P-1	07/81	SO_2	Coal	10.7	4.3	13.2	5.0
P-1	12/81	SO_2	Coal	7.3	4.8	9.8	5.4
P-1	06/80	NO_x	Coal	5.8	4.6	---	---
P-1	07/81	NO_x	Coal	7.6	6.1	6.8	3.8
P-1	12/81	NO_x	Coal	15.8	7.7	18.6	8.8
P-2	06/80	SO_2	Coal	18.8	7.5	---	---
P-2	05/81	SO_2	Coal	14.6 *	5.8	16.0 *	5.9
P-2	07/81	SO_2	Coal	8.6	3.9	12.2	4.2
P-2	12/81	SO_2	Coal	9.9	2.2	4.3	3.5
P-2	06/80	NO_x	Coal	17.0	6.1	---	---
P-2	05/81	NO_x	Coal	12.7	4.6	14.4	5.2
P-2	07/81	NO_x	Coal	2.5	2.2	5.0	2.4
P-2	12/81	NO_x	Coal	13.1	6.8	24.6	7.0
P-1	05/82	SO_2	Coal	28.3 *	3.5	26.7 *	4.9
P-1	05/82	NO_x	Coal	13.5	4.9	16.4	5.0
P-2	04/82	SO_2	Coal	9.6 *	6.0	11.3 *	7.3
P-2	04/82	NO_x	Coal	11.6 *	5.9	11.6 *	5.0

* 6 Reference Method runs instead of 9 runs

LSI MONITOR PERFORMANCE

SOURCES WITHOUT FGD EMISSIONS CONTROL SYSTEMS

Source Code	Test Date	Pollutant Gas	Fuel Burned	Pollutant Concentration		System [lbs/10^6 Btu]	
				Relative Accuracy (%)	95% Confidence Level (%)	Relative Accuracy (%)	95% Confidenc Level (%)
C-34	10/77	SO_2	Coal	19.7	6.0	---	---
C-34	10/78	SO_2	Coal	2.2	1.4	12.8	2.3
C-34	12/79	SO_2	Coal	10.1	4.3	9.8	2.6
C-34	10/77	NO_x	Coal	15.6	3.8	---	---
C-34	10/78	NO_x	Coal	22.7	6.7	32.4	8.0
C-34	10/79	NO_x	Coal	25.6	7.5	26.7	6.7
C-5	08/80	SO_2	Coal	9.5	3.8	---	---
C-5	08/80	NO_x	Coal	8.3	5.3	---	---
G-9	09/81	SO_2	Coal	9.0	2.7	5.6	4.8
H-1	12/81	SO_2	Coal	8.9	4.7	7.7	4.8
M-5	10/80	SO_2	Coal	18.4	9.0	15.5	8.3
M-5	10/80	NO_x	Coal	7.3	3.2	10.2	3.2
R-1	12/81	SO_2	Coal	18.5	3.5	14.2	3.6
R-1	12/81	NO_x	Coal	23.5	10.2	28.1	10.9
S-1	03/82	SO_2	Coal	3.8	2.0	16.0	3.3
S-2	02/82	SO_2	Coal	4.1	2.2	11.1	2.2
S-3	03/82	SO_2	Coal	22.5	6.3	17.7	4.6

DUPONT MONITOR PERFORMANCE

SOURCES WITHOUT FGD EMISSIONS CONTROL SYSTEM

Source Code	Test Date	Pollutant Gas	Fuel Burned	Pollutant Concentration		System [lbs/10^6 Btu]	
				Relative Accuracy (%)	95% Confidence Level (%)	Relative Accuracy (%)	95% Confidence Level (%)
A-3	08/80	NO_x	Coal	16.6	4.0	16.4	3.8
N-7	02/81	NO_x	Oil	9.0	6.0	11.6	6.1
N-8	12/80	SO_2	Oil	11.7	3.4	15.5	3.5
N-8	12/80	NO_x	Oil	17.5	6.5	13.4	8.6
N-9	11/80	SO_2	Oil	14.1	2.7	17.8	4.0
N-9	11/80	NO_x	Oil	10.0	3.6	13.6	1.3
N-10	12/80	SO_2	Oil	4.5	3.3	7.0	3.4
N-10	12/80	NO_x	Oil	16.6	4.7	19.0	4.5
T-2	02/82	SO_2	Coal	9.3	8.4	10.1	8.3
Q-4	01/82	SO_2	Coal	3.5	2.8	10.2	3.8
Q-4	03/82	SO_2	Coal	17.5	5.4	12.1	5.9

DUPONT MONITOR PERFORMANCE

SOURCES WITH FGD EMISSIONS CONTROL SYSTEM

Source Code	Test Date	Pollutant Gas	Fuel Burned	Pollutant Concentration		System [lbs/10^6 Btu]	
				Relative Accuracy (%)	95% Confidence Level (%)	Relative Accuracy (%)	95% Confidence Level (%)
B-2/3	01/81	SO_2	Coal	passed	---	6.7	2.3
B-2/3	11/81	SO_2	Coal	10.1	3.5	7.2	3.0
B-2/3	04/82	SO_2	Coal	23.2	16.8	19.7	16.4

CONTRAVES MONITOR PERFORMANCE

SOURCES WITH FGD EMISSIONS CONTROL SYSTEM

Source Code	Test Date	Pollutant Gas	Fuel Burned	Pollutant Concentration		System [lbs/10^6 Btu]	
				Relative Accuracy (%)	95% Confidence Level (%)	Relative Accuracy (%)	95% Confidence Level (%)
D-1	09/80	SO_2	Coal	5.8	5.3	18.8	10.0
D-1	07/81	SO_2	Coal	9.2	5.0	9.5	3.5
D-1	12/81	SO_2	Coal	55.2	19.2	99.0	24.5
D-1	03/82	SO_2	Coal	52.0 *	6.3	61.8 *	10.0

* 6 Reference Method runs instead of 9 runs

CONTRAVES MONITOR PERFORMANCE

SOURCES WITHOUT FGD EMISSIONS CONTROL SYSTEM

Source Code	Test Date	Pollutant Gas	Fuel Burned	Pollutant Concentration		System [lbs/10^6 Btu]	
				Relative Accuracy (%)	95% Confidence Level (%)	Relative Accuracy (%)	95% Confidence Level (%)
F-4S	04/81	SO_2	Coal	3.7	1.8	---	---
F-4S	04/81	NO_x	Coal	15.6	2.5	---	---
F-4N	04/81	SO_2	Coal	29.1	3.7	---	---
F-4N	04/81	NO_x	Coal	32.3	2.0	---	---
F-4N	09/81	SO_2	Coal	16.4	4.9	7.5	4.6
F-4N	09/81	NO_x	Coal	8.9	6.7	13.1	7.8

EDC MONITOR PERFORMANCE

SOURCES WITHOUT FGD EMISSIONS CONTROL SYSTEM

Source Code	Test Date	Pollutant Gas	Fuel Burned	Pollutant Concentration		System [lbs/10^6 Btu]	
				Relative Accuracy (%)	95% Confidence Level (%)	Relative Accuracy (%)	95% Confidence Level (%)
E-123	08/80	NO_x	Oil	21.2	6.9	17.1	7.8
E-45	08/80	NO_x	Oil	5.1	2.8	7.8	5.2
J-1	12/81	SO_2	Coal	18.0	3.5	32.0	6.7

EDC MONITOR PERFORMANCE

SOURCES WITH FGD EMISSION CONTROL SYSTEM

Source Code	Test Date	Pollutant Gas	Fuel Burned	Pollutant Concentration		System [lbs/10^6 Btu]	
				Relative Accuracy (%)	95% Confidence Level (%)	Relative Accuracy (%)	95% Confidence Level (%)
K-3	06/80	SO_2	Coal	19.6	---	---	---
K-3	07/81	SO_2	Coal	8.6	4.6	11.9	5.5

CSI MONITOR PERFORMANCE

SOURCE WITHOUT FGD EMISSION CONTROL SYSTEM

Source Code	Test Date	Pollutant Gas	Fuel Burned	Pollutant Concentration		System [lbs/10^6 Btu]	
				Relative Accuracy (%)	95% Confidence Level (%)	Relative Accuracy (%)	95% Confidence Level (%)
Q-4	01/82	SO_2	Coal	4.7	3.4	10.5	3.3
Q-4	03/82	SO_2	Coal	13.1	4.5	7.7	4.9